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6. AUTHOR(S)
Dr. John B. Diebold

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The Trustees of Columbia University
in the City of New York
1210 Amsterdam Ave., MC 2205
New York, NY 10027

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Office of Naval Research
Dr. Joseph H. Kravitz, ONR 322GG
Ballston Centre Tower One - 800 North Quincy St.
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13. ABSTRACT *(Maximum 200 words)*

As part of *USNS Bowditch* Cruise 621098, a high resolution MCS reflection survey of the Persian Gulf, 48 NAVO-supplied sonobuoys were deployed and recorded. 32 of these returned useful data, the analysis if which is presented here. The principal purpose of this study was to determine detailed shallow velocity structure which would complement those obtained as part of the MCS processing and analysis. Two analysis methods were employed: interactive ray tracing and determination of the angle of critical reflection from the seafloor. This latter method can tell us the velocity of sediment on the seafloor, which cannot be determined using "normal" means. Ray tracing returned velocity functions extending as deep as 2 km in some cases. An important result is that in an area of the central gulf, there exists a thin, high velocity layer not far below the seafloor. It is difficult to measure the thickness of this layer, but its velocity and depth are well constrained.

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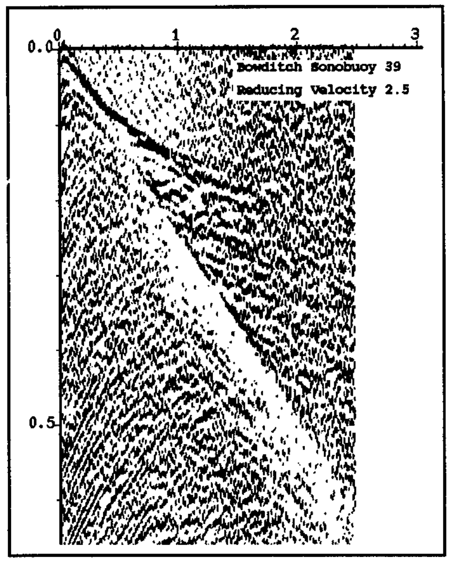
N00014-97-1-1035 Final Report:

Measurement of shallow sedimentary velocity structure with CDP gathers and sonobuoy profiles.

John Diebold, Lamont-Doherty Earth Observatory

Acquisition

During cruise 621098, July – Aug 1998, 48 NAVO-supplied SSQ57 sonobuoys were deployed during a high resolution 48 channel multichannel seismic reflection survey. 31 of the buoys returned useful records. The others failed to activate, "died" early, were snagged by the 600 meter towed hydrophone array, or produced unacceptably noisy data. In one case, due to a mishap on the bridge, the ship reversed its direction and backed up on the buoy, nearly destroying the MCS equipment in the process. Another less severe ship-related problem was that occasionally, the ship speed changed during the time a buoy was recorded, complicating (but not making impossible) the process of assigning offsets to each recorded trace.



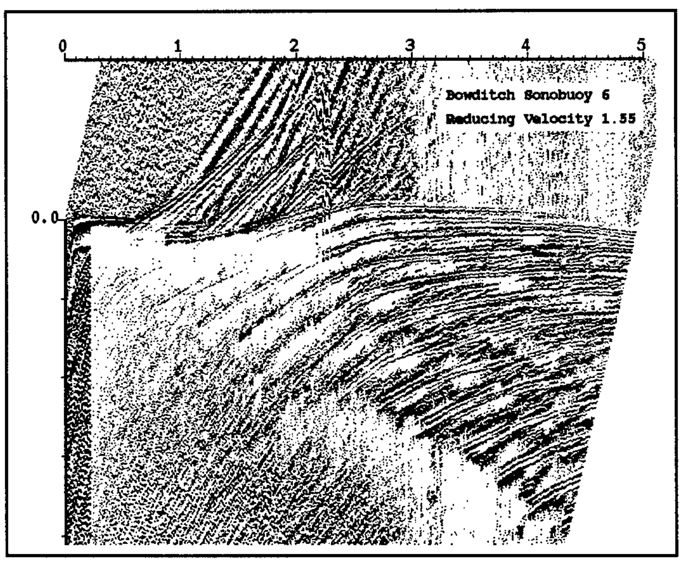


Figure 1 (above) A poor sonobuoy record. Good enough to obtain a velocity function, but exhibiting a weak signal and the "AGC" effect described below.

Figure 2 (left) The effect of changes in ship speed during recording of sonobuoy 6. There are also problems with gain chages. Nevertheless, this is a useful record.

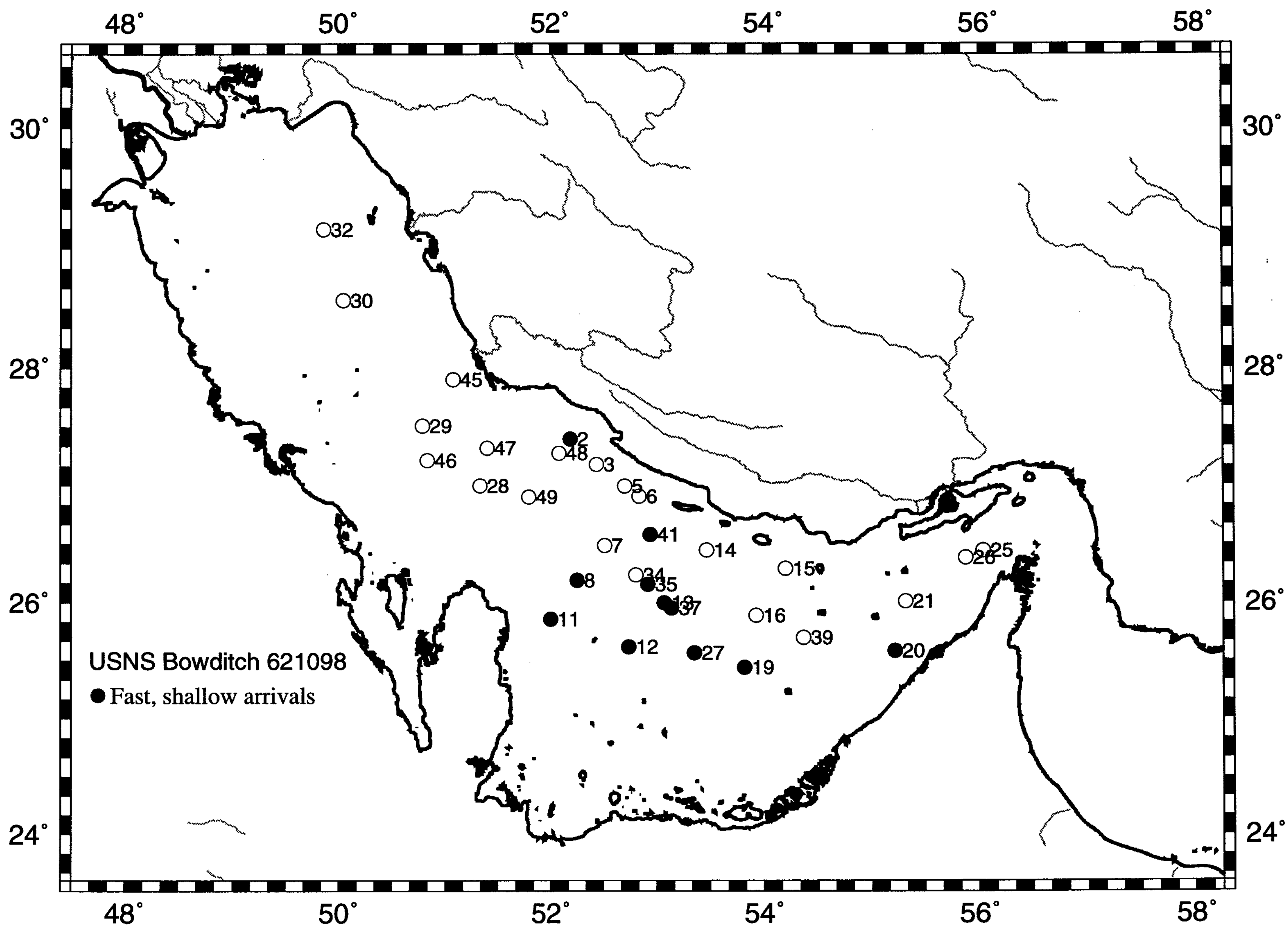
The buoys were recorded using a NAVO-supplied antenna and receiver, whose audio output was fed into the Lamont-Doherty MCS acquisition system and recorded as an auxiliary channel. On some of the records [cf. Figs 1, 2 above] the traces exhibit an "AGC' –like behavior, the gain appearing to lower during high amplitude events, and recovering slowly. Since this behavior only appeared on some buoys, I assume it was due to a flaw in the buoy's electronics, and not the radio receiver. The Lamont high

resolution MCS team have subsequently recorded other buoys with the same acquisition system [and our own radio and antenna] without any of this symptomology. Nevertheless, the 31 successful buoys contain the arrivals and information necessary to successfully achieve the program goals of this study, which were to determine shallow velocity structure in the Persian Gulf. We also determined velocity structures going as deep as 1 km, which were useful for shipboard processing of the reflection data.

Beyond achievement of the basic program goals, there are two principal successes of this study. First, I mapped areas in the gulf in which one or more high velocity layers lie close to the sea floor, overlain by a thin veneer of slow, recent sediments. It is unlikely that these layers will be detected or imaged by the reflection data. These layers play a very important role in the lateral propagation of sound in this shallow sea. Second, I demonstrated the validity of a unique method of analysis which can determine the sound velocity at [or very close to] the seafloor.

Table 1: Sonobuoys used in this study

buoy	Line	D (m)	Tape	Shot	J.D.	Time	Latitude	Longitude
2	2	78	96	2970	212	2:06:02	27oN 23.9171'	52oE 11.4261'
3	2	81.82	111	5694	212	5:53:03	27oN 10.8353'	52oE 26.3048'
5	2		126	8325	212	9:32:24	26oN 59.8538'	52oE 42.0991'
6	3		137	263	212	12:40:25	26oN 51.3673'	52oE 50.2658'
7	3		163	4531	212	19:46:17	26oN 29.3435'	52oE 30.8010'
9	3		179	7902	213	00:27:18	26oN 11.5931'	52oE 15.1516'
11	4		203	351	213	6:37:25	25oN 51.5919'	52oE 0.0515'
12	5	32	248	113	213	17:57:18	25oN 37.1179'	52oE 44.2803'
13	5	76	277	5100	214	3:26:41	25oN 59.8775'	53oE 4.3377'
14	5	93	309	10781	214	11:29:33	26oN 26.7978'	53oE 27.8893'
15	8	70.5	354	181	215	00:29:32	26oN 17.2696'	54oE 11.6072'
16	8	74.42	378	4524	215	08:20:24	25oN 53.2868'	53oE 55.4241'
19	9	45.5	419	1950	215	19:47:32	25oN 26.4031'	53oE 48.8908'
20	10		486	55	216	16:04:42	25oN 34.8349'	55oE 12.8940'
21	11	91	511	89	216	23:04:04	26oN 00.5566'	55oE 18.9963'
25	13	82	562	579	217	13:08:56	26oN 26.6337'	56oE 2.0499'
26	13	63.9	569	1975	217	15:05:13	26oN 22.8816'	55oE 54.4278'
27	17	31.9	714	8477	219	09:36:41	25oN 33.9083'	53oE 20.9841'
28	19	77	830	7880	220	20:52:26	27oN 00.0812'	51oE 19.9105'
29	19	60.2	865	14101		5:30:59	27oN 30.5844'	50oE 47.5056'
30	20	57.7	925	9527		00:34:24	28oN 34.3092'	50oE 2.9241'
32	22		982	546	222	15:18:23	29oN 9.4026'	49oE 51.9763'
34	25		1177	3390		16:33:47		
35	25	74.9	1184	4536	224	18:09:17	26oN 09.3497'	52oE 55.1642'
37	25		1198	7084		21:41:38	25oN 57.0359'	53oE 08.4471'
39	27	62	1259	214		13:26:38	25oN 41.6738'	54oE 21.7015'
41	25	85.24	1336	412	226	10:37:53	26oN 34.9571'	52oE 56.4409'
45	40	50.8	1797	109		08:10:42	27oN 54.2538'	51oE 04.7317'
46	41		1878	5947		04:51:37	27oN 13.0121'	50oE 50.3139'
47	42	76	1907	2764		12:59:55	27oN 19.3076'	51oE 23.9757'
48	44	60	1955	1451		00:55:18	27oN 16.4040'	52oE 4.8702'
49	44	65.9	1972	4671		05:23:39	26oN 58.6522'	51oE 51.1081'



Diebold -- Figure 3

Processing

During the cruise, the auxiliary channels corresponding to seismic shots recorded on each "live" sonobuoy were copied from the reflection survey SEG-D field tapes and re-recorded as SEG-Y data traces on IBM-format 3480 tape cartridges. Raster files of each buoy were made with two filter schemes; one with a broad frequency range [12 – 250 Hz] and another with lower frequencies only [12 – 80 Hz]. In each of the images shown in this report, the vertical scale is two-way traveltime in seconds, and the horizontal scale is offset, in km. In general, six or seven km was the maximum useful offset. Offsets were determined by modeling the direct arrival and the seafloor reflection.

Both images were used for analysis. In general, the broad frequency images were best for analysis of shallow refracted arrivals, and the low frequency version was better for determining deep structure, detecting precritically reflecting horizons, and analyzing the train of water column multiples to determine seafloor velocities.

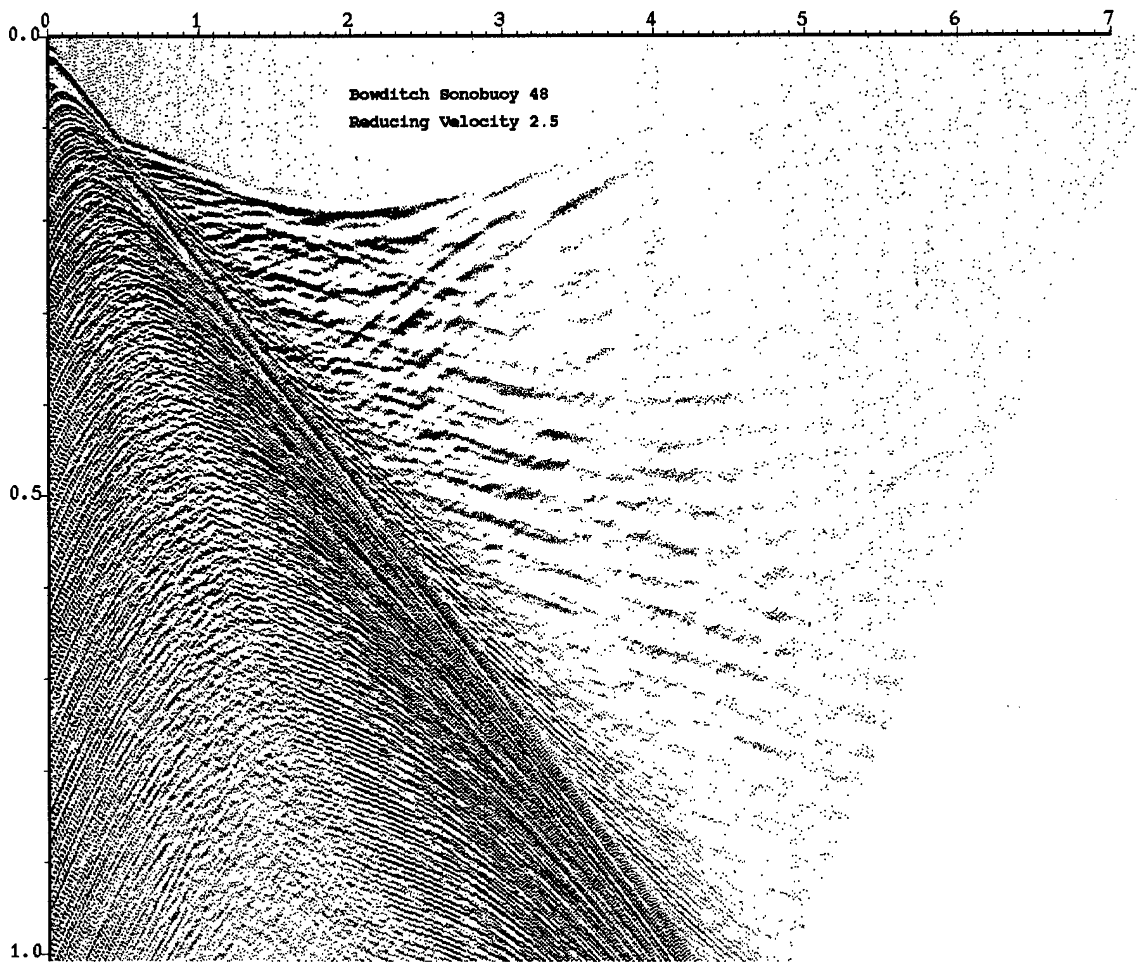


Fig. 4: Buoy number 48 – broad frequency range

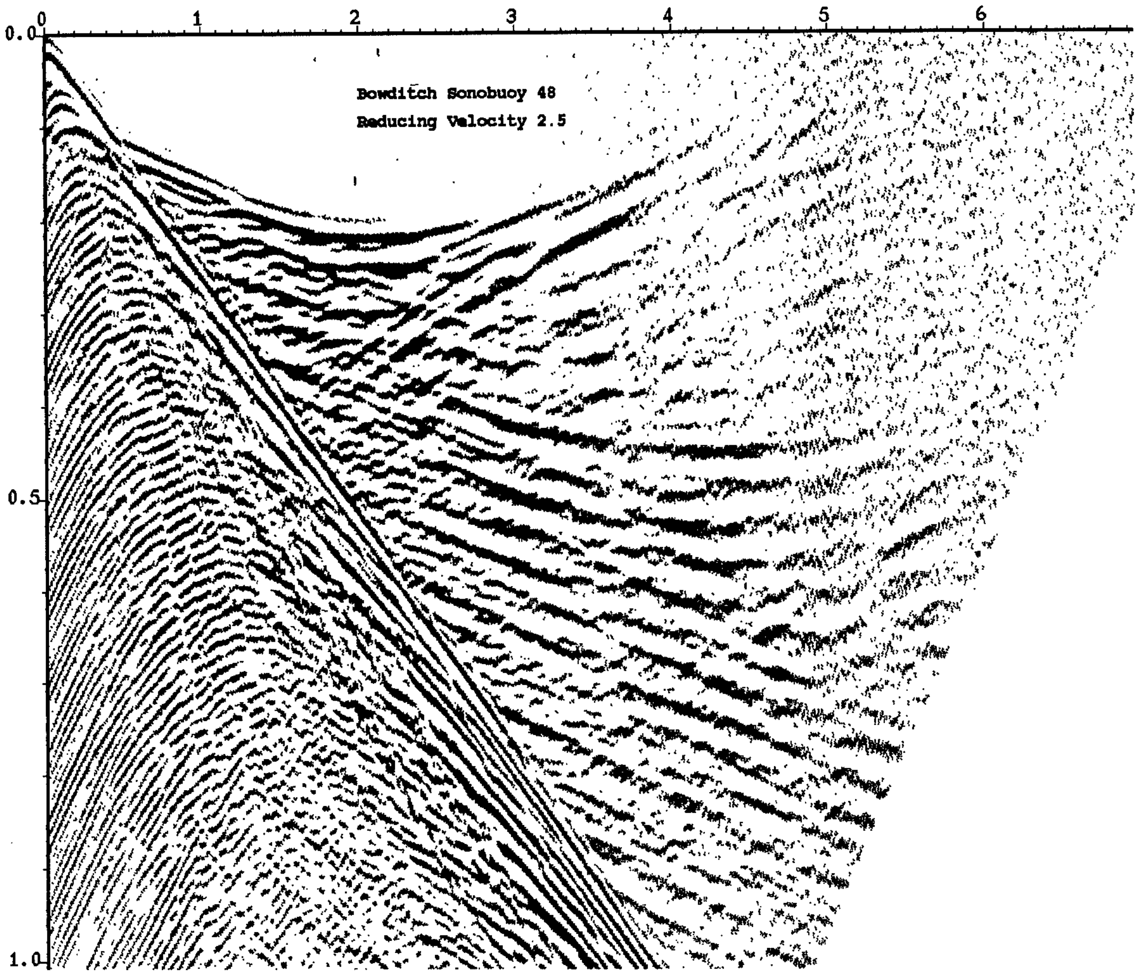


Fig 5: Buoy number 48 – low frequencies

Analysis

All analysis was performed using JDseis interactive raytracing software, copies of which, along with installation, instruction and documentation, were delivered to NAVO in Bay St. Louis during an earlier project under the direction of Nelson Latourneau. JDseis is an image based package, which performs many data manipulation and analysis functions, including velocity analysis, including 1-D raytracing for sonobouy and other wide angle reflection seismic record sections. All of the data figures in this report were generated by JDseis.

The first step in analysis is to determine source-receiver offsets. This was done by superimposing predicted direct arrival and the seafloor reflection times on the rasterized images, and adjusting zero – offset and ship speed parameters until a good fit was achieved. In cases like that of buoy 6 [Fig 2, above] the ship speed was changing enough to distort travel times. In these cases, a horizontal stretching procedure accounted for the non-linear variation in shot-to-shot offset.

Water Column multiples and upper sediment velocity

One of the most useful enhancements that JDseis can make to sonobuoy data is the application of a reducing velocity. Each data trace is shifted to an earlier "reduced" time, according to its offset:

$$T_{RED} = T - X \ / \ V_{RED}$$

Where X is the offset of the trace. After this shift, any linear trend in the data having an apparent velocity equal to V_{RED} will become horizontal. In the two data examples shown above, a reducing velocity of 2.5 km/sec has been applied. The result is an increased ability to detect subtle differences between various seismic arrivals from the sediment column.

As a check on the determination of sonobuoy trace offsets, I apply a reducing velocity equal to the assumed horizontal sound velocity in the upper water column. If the offsets are correct, the shifted direct arrival will become horizontal and equal to

$$T_{RED} = \text{zero.}$$

If not, adjustments are made. It was during the application of this process to some shallow water sonobuoys that I was analyzing for Dr. LaTourneau that I noticed a curious effect – distinct changes in the amplitude of the seafloor multiples, which formed a linear trend in the time reduced data. I realized that these corresponded to the critical points of the seafoor reflection and its multiples.

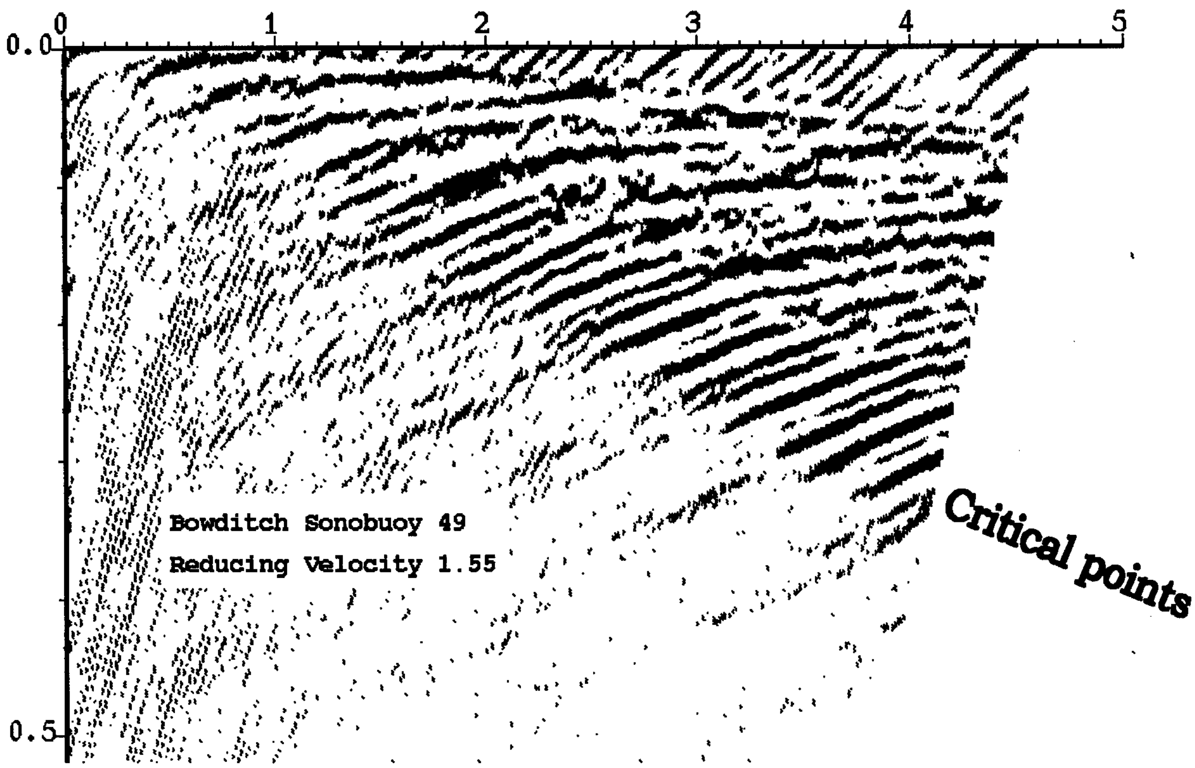


Fig. 6: Sonobuoy 49; water column multiples

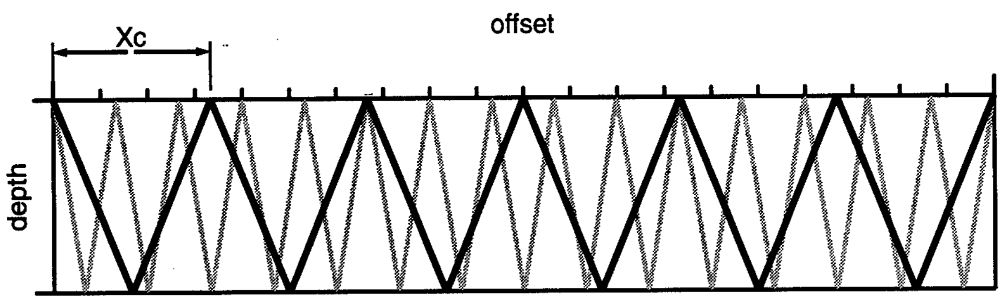


Fig 7: Precritically reflected multiples (gray ray) have relatively low amplitudes. At the critical point (solid ray) and beyond, the seafloor reflection coefficient becomes unity, and arrival amplitudes suddenly increase.

A simple analysis indicated that the apparent velocity [dT/dX] of the high amplitude onset depended on the water velocity and that of the layer below; the seafloor:

$$T_{CRIT} / X_{CRIT} = V_{SEAFLOOR} / V_{WATER}^{2}$$

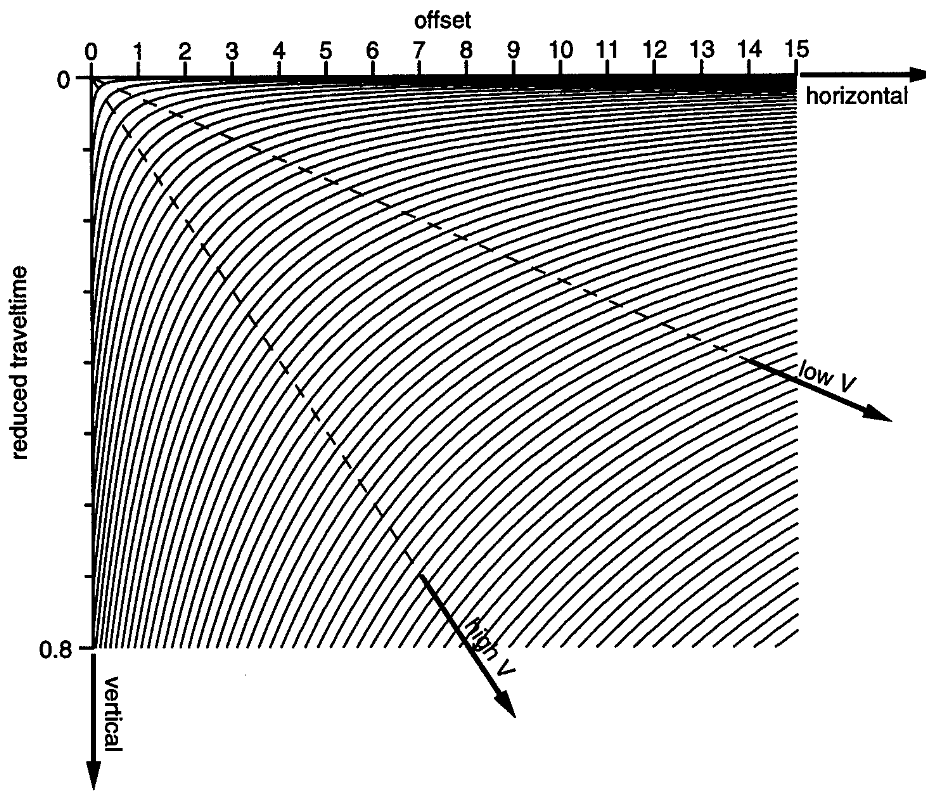


Fig. 8: Line drawing of seafloor multiples with reducing velocity equal to water velocity. Critical points lie along straight lines, whose angle depends on seafloor velocity.

The critical arrivals necessary for this method's success were observed in all of the Bowditch sonobuoys, suggesting either either that the seafloor sediments were fairly

competent everywhere we made measurements, or that soft, mucky bottoms, if present, did not prevent the arrivals from being generated. Further analysis, modeling and testing would be required to determine if the latter case is possible. Using this method, seafloor velocities of all buoys were determined. The error in this measurement appears to be in the neighborhood of +/- 25 m/sec. Accuracy could be imoproved through a scheme of forward modeling with synthetic seismograms, but such a scale of effort was beyond the level of support of this contract. Thicknesses of the upper sub-seafloor layers were determined by fitting the intercept times of the first visible refracted arrival. The resulting accuracy is very high in the cases described next (shallow high velocity layers) and somewhat variable for the other sonobuoys, depending on the underlying velocity structure. For example in buoy 48 [Fig. 4] there is a visible, shallow refraction which constrains the upper velocity quite well.

Shallow high velocity layers

Eleven of the sonobuoy records exhibit early refracted arrivals which indicate shallow layers with high velocities [between 1.9 and 3 km/sec] The strength and shape of these arrivals indicate that the layers have positive velocity gradients. The characteristic gap between the first arrivals produced by these layers and first arrivals from layers below indicates that the layers are underlain by other layers having lower velocities. It is expected that those low velocity layers are similar to those determined for nearby sonobuoys not having upper, fast layers. Determination of average velocities for low velocity layers is possible when there are visible precritical reflections from within and/or the base of those layers. When such arrivals were not seen, reasonable values were assumed.

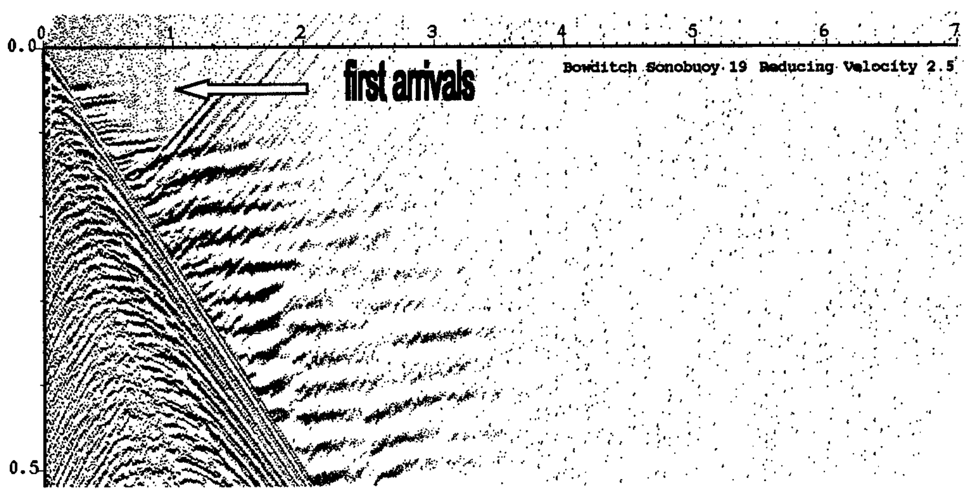


Fig. 9: Sonobuoy 19, broad frequency range. Shallow, high velocity layering

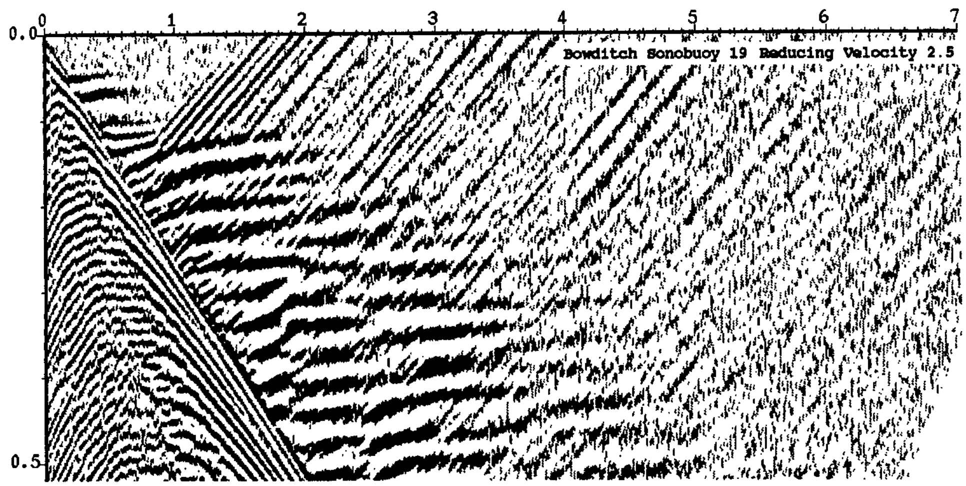


Fig. 10: Sonobuoy 19, low frequencies only.

The reflection coefficient of the shallow fast layer is quite high, and multiples, caused by reverberation through the water column and uppermost slow sediments, are present throughout the section, complicating the analysis. The same effect causes an added set (or sets) of arrivals, superimposed on the water column multiples.

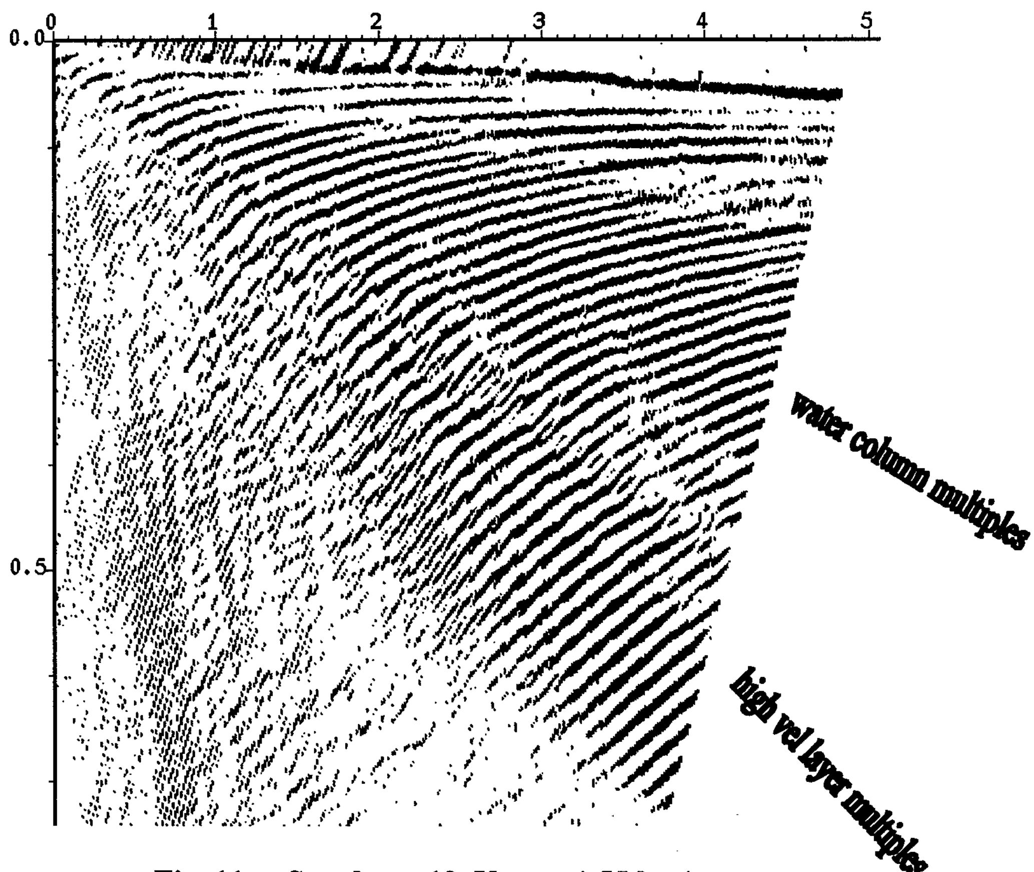


Fig. 11 : Sonobuoy 19, V_{RED} = 1.55 km/sec

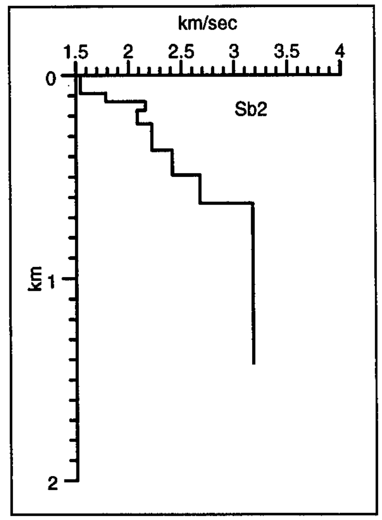
It is still possible to determine the seafloor velocity, and in this case, the top velocity of the underlying high velocity layer, as well. This value agrees well with that determined by ray tracing of the refracted arrivals. This observation of superimposed sets of water column multiples is new to this data set. It is very likely that further examination of this phenomenon will allow us to determine shallow velocity structure in even more detail in the future.

Tabulated velocity results

Sb2

NL	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.113	1.55	1.55	0.088	0.088	0.113
2	0.16	1.79	1.79	0.13	0.042	0.047
3	0.199	2.16	2.16	0.172	0.042	0.039
4	0.265	2.08	2.08	0.24	0.069	0.066
5	0.379	2.22	2.22	0.367	0.127	0.114
6	0.482	2.41	2.41	0.491	0.124	0.103
7	0.585	2.67	2.67	0.629	0.138	0.103
8	1.085	3.17	3.17	1.421	0.793	0.5

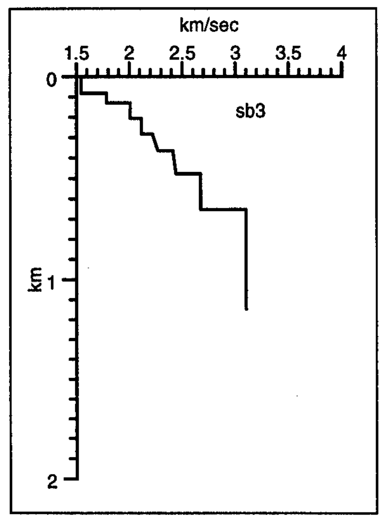
Good buoy, Moderate Signal-to-Noise.



sb3

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.104	1.55	1.55	0.081	0.081	0.104
2	0.16	1.79	1.79	0.131	0.05	0.056
3	0.235	2.01	2.01	0.206	0.075	0.075
4	0.307	2.115	2.115	0.282	0.076	0.072
5	0.379	2.22	2.27	0.363	0.081	0.072
6	0.472	2.41	2.44	0.476	0.113	0.093
7	0.604	2.67	2.67	0.652	0.176	0.132
8	0.926	3.1	3.1	1.151	0.499	0.322

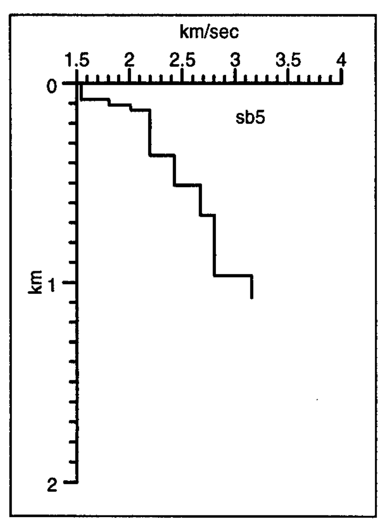
No phone drop until 270m. Moderate S/N



sb5

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.104	1.55	1.55	0.081	0.081	0.104
2	0.133	1.81	1.81	0.107	0.026	0.029
3	0.16	2.01	2.02	0.134	0.027	0.027
4	0.368	2.195	2.195	0.362	0.228	0.208
5	0.491	2.425	2.425	0.511	0.149	0.123
6	0.604	2.67	2.67	0.662	0.151	0.113
7	0.82	2.8	2.8	0.965	0.302	0.216
8	0.892	3.15	3.15	1.078	0.113	0.072

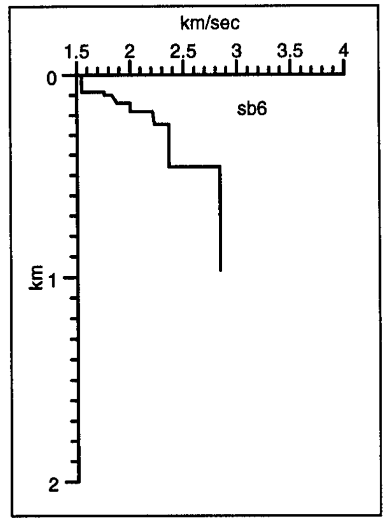
Good Buoy, Good S/N



sb6

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.108	1.55	1.55	0.084	0.084	0.108
2	0.127	1.76	1.76	0.1	0.017	0.019
3	0.168	1.83	1.88	0.138	0.038	0.041
4	0.211	2.004	2.004	0.182	0.043	0.043
5	0.268	2.209	2.229	0.245	0.063	0.057
6	0.449	2.36	2.36	0.458	0.214	0.181
7	0.81	2.835	2.835	0.97	0.512	0.361

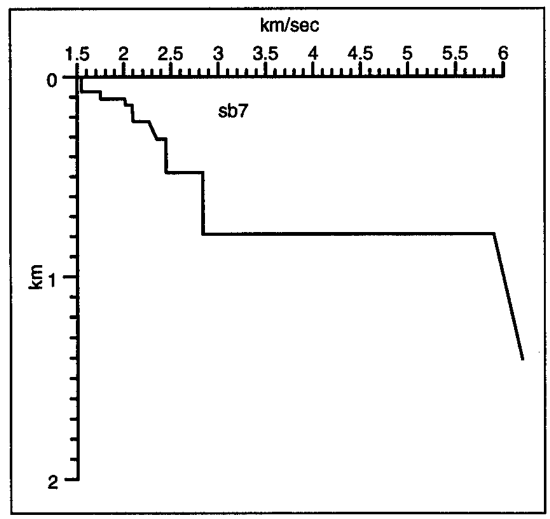
Speed changes, gain changes, but OK



sb7

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.093	1.55	1.55	0.072	0.072	0.093
2	0.133	1.75	1.75	0.107	0.035	0.04
3	0.164	2.01	2.02	0.138	0.031	0.031
4	0.243	2.087	2.097	0.221	0.083	0.079
5	0.321	2.268	2.349	0.311	0.09	0.078
6	0.459	2.45	2.45	0.48	0.169	0.138
7	0.676	2.84	2.84	0.788	0.308	0.217
8	0.882	5.9	6.2	1.411	0.623	0.206

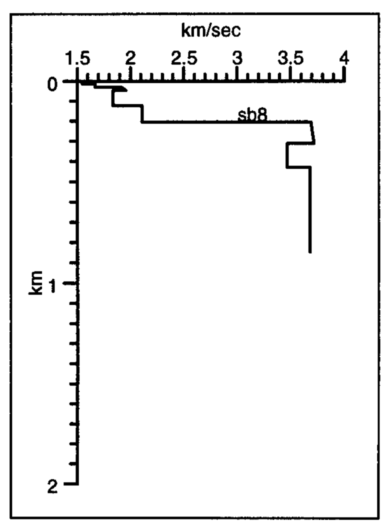
Weak, "kinky" from speed changes.



sb8

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.016	1.55	1.55	0.012	0.012	0.016
2	0.034	1.67	1.67	0.027	0.015	0.018
3	0.052	1.91	1.96	0.045	0.017	0.018
4	0.135	1.84	1.84	0.122	0.077	0.083
5	0.214	2.11	2.11	0.204	0.083	0.079
6	0.271	3.689	3.719	0.31	0.106	0.057
7	0.339	3.47	3.47	0.428	0.118	0.068
8	0.567	3.68	3.68	0.848	0.42	0.228

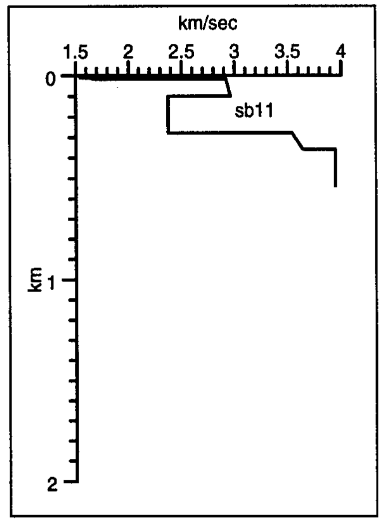
Good S/N



sb11

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.014	1.55	1.55	0.011	0.011	0.014
2	0.02	1.67	1.67	0.016	0.005	0.006
3	0.076	2.92	2.96	0.098	0.082	0.056
4	0.226	2.374	2.374	0.276	0.178	0.15
5	0.271	3.54	3.64	0.357	0.081	0.045
6	0.365	3.945	3.945	0.542	0.185	0.094

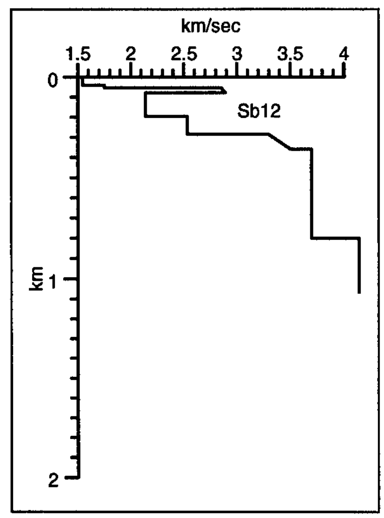
No signal until 225 meters. Very shallow fast arrivals. Random spikes of noise.



Sb12

NL	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.05	1.55	1.55	0.039	0.039	0.05
2	0.066	1.75	1.75	0.053	0.014	0.016
3	0.082	2.85	2.89	0.076	0.023	0.016
4	0.193	2.14	2.14	0.194	0.119	0.111
5	0.264	2.53	2.53	0.284	0.09	0.071
6	0.307	3.292	3.501	0.357	0.073	0.043
7	0.546	3.699	3.699	0.799	0.442	0.239
8	0.677	4.138	4.138	1.07	0.271	0.131

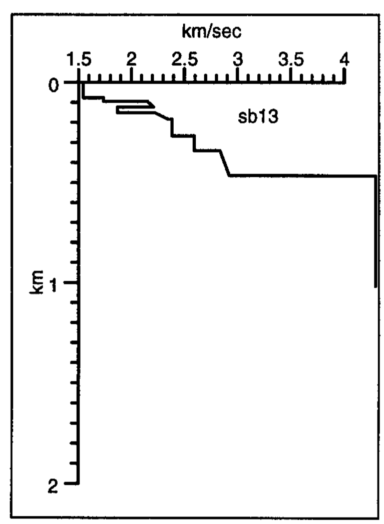
Loud at first, but complete data. Ringy shallow fast arrivals.



sb13

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.099	1.55	1.55	0.077	0.077	0.099
2	0.12	1.74	1.74	0.095	0.018	0.021
3	0.146	2.15	2.21	0.123	0.028	0.026
4	0.173	1.87	1.87	0.149	0.025	0.027
5	0.203	2.219	2.348	0.183	0.034	0.03
6	0.272	2.383	2.383	0.265	0.082	0.069
7	0.329	2.59	2.59	0.339	0.074	0.057
8	0.416	2.83	2.92	0.464	0.125	0.087
9	0.676	4.289	4.289	1.021	0.558	0.26

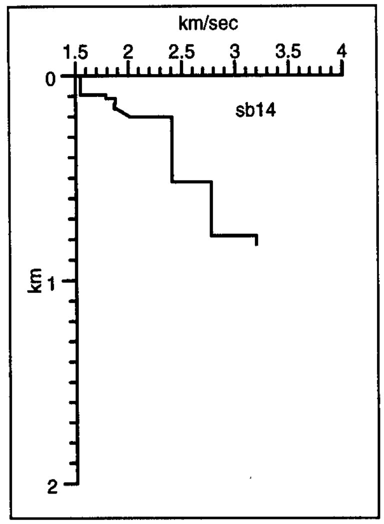
Excellent, simple multiples, slight “AGC” in postcritical arrivals.



sb14

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.119	1.55	1.55	0.092	0.092	0.119
2	0.14	1.79	1.79	0.111	0.019	0.021
3	0.166	1.88	1.88	0.135	0.024	0.026
4	0.193	1.87	1.87	0.161	0.025	0.027
5	0.234	1.889	2.018	0.201	0.04	0.041
6	0.499	2.4	2.4	0.519	0.318	0.265
7	0.689	2.77	2.77	0.782	0.263	0.19
8	0.72	3.19	3.19	0.831	0.049	0.031

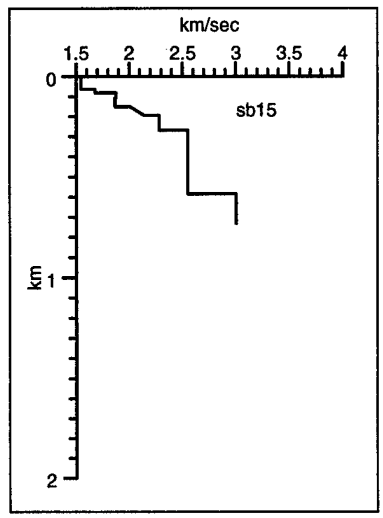
Distorted signal until 75 m. Exellent thereafter.



sb15

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.082	1.55	1.55	0.064	0.064	0.082
2	0.103	1.68	1.68	0.081	0.018	0.021
3	0.129	1.88	1.88	0.106	0.024	0.026
4	0.176	1.87	1.87	0.15	0.044	0.047
5	0.217	2.01	2.139	0.192	0.043	0.041
6	0.284	2.28	2.28	0.268	0.076	0.067
7	0.531	2.55	2.55	0.583	0.315	0.247
8	0.632	3	3	0.735	0.152	0.101

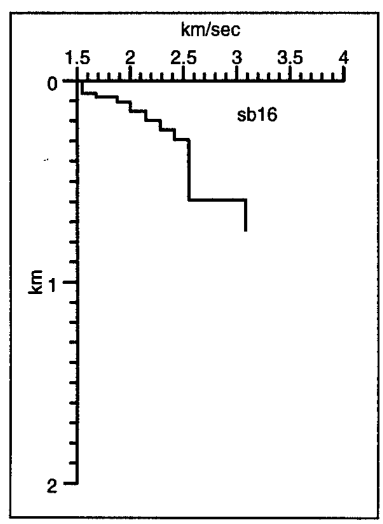
Noisy but entirely adequate.



sb16

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.082	1.55	1.55	0.064	0.064	0.082
2	0.103	1.68	1.68	0.081	0.018	0.021
3	0.129	1.88	1.88	0.106	0.024	0.026
4	0.176	2	2	0.153	0.047	0.047
5	0.217	2.149	2.149	0.197	0.044	0.041
6	0.258	2.28	2.28	0.243	0.047	0.041
7	0.299	2.415	2.415	0.293	0.05	0.041
8	0.531	2.55	2.55	0.589	0.296	0.232
9	0.632	3.08	3.08	0.744	0.156	0.101

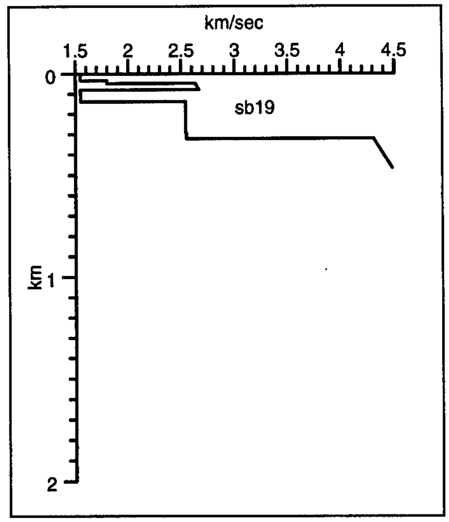
Distorted beginning, then OK, but died at 500 m. Maybe snagged a bird.



sb19

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.041	1.55	1.55	0.032	0.032	0.041
2	0.058	1.8	1.8	0.047	0.015	0.017
3	0.082	2.63	2.67	0.079	0.032	0.024
4	0.156	1.55	1.55	0.136	0.057	0.074
5	0.278	2.54	2.54	0.291	0.155	0.122
6	0.302	2.547	2.547	0.322	0.031	0.024
7	0.369	4.305	4.485	0.469	0.147	0.067

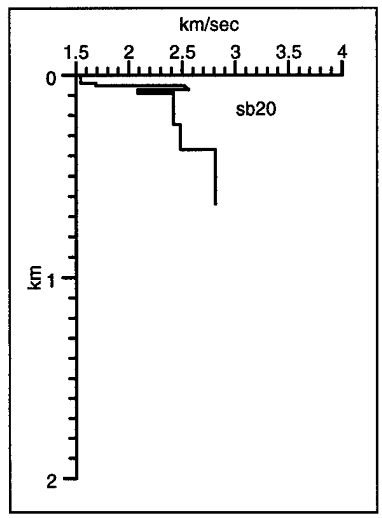
Good S/N – see figures.



sb20

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.05	1.55	1.55	0.039	0.039	0.05
2	0.066	1.69	1.69	0.052	0.014	0.016
3	0.082	2.52	2.56	0.073	0.02	0.016
4	0.099	2.08	2.08	0.09	0.018	0.017
5	0.227	2.42	2.42	0.245	0.155	0.128
6	0.325	2.48	2.48	0.367	0.122	0.098
7	0.522	2.81	2.81	0.643	0.277	0.197

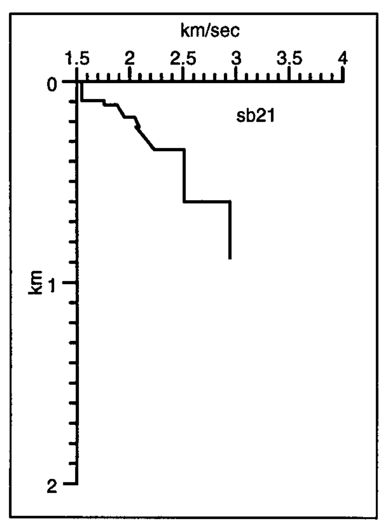
Good S/N



sb21

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.121	1.55	1.55	0.094	0.094	0.121
2	0.144	1.76	1.76	0.114	0.02	0.023
3	0.209	1.88	1.95	0.176	0.062	0.065
4	0.256	2.05	2.09	0.225	0.049	0.047
5	0.363	2.06	2.23	0.34	0.115	0.107
6	0.569	2.51	2.51	0.598	0.259	0.206
7	0.762	2.94	2.94	0.882	0.284	0.193

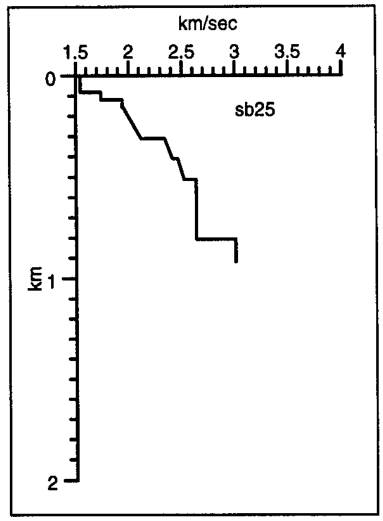
Distorted early, then good, but fades out at 1100 meters offset. Poor resolution of seafloor V.



sb25

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.106	1.55	1.55	0.082	0.082	0.106
2	0.149	1.74	1.74	0.12	0.037	0.043
3	0.186	1.945	1.945	0.156	0.036	0.037
4	0.339	1.95	2.12	0.311	0.156	0.153
5	0.422	2.34	2.41	0.41	0.099	0.083
6	0.503	2.46	2.52	0.511	0.101	0.081
7	0.727	2.63	2.63	0.805	0.295	0.224
8	0.805	3	3	0.922	0.117	0.078

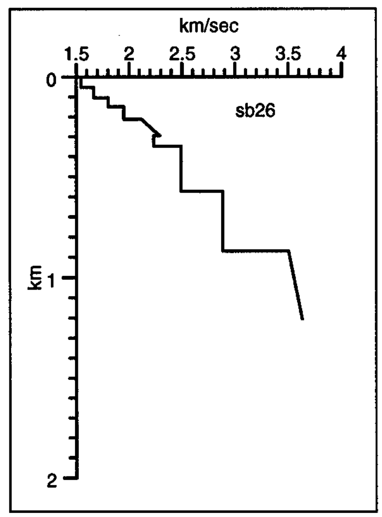
Distorted beginning, but then good until it fades at 2600 meters.



sb26

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.068	1.55	1.55	0.053	0.053	0.068
2	0.13	1.67	1.67	0.104	0.052	0.062
3	0.178	1.805	1.805	0.148	0.043	0.048
4	0.244	1.95	1.95	0.212	0.064	0.066
5	0.319	2.12	2.29	0.295	0.083	0.075
6	0.364	2.23	2.23	0.345	0.05	0.045
7	0.546	2.49	2.49	0.572	0.227	0.182
8	0.751	2.88	2.88	0.867	0.295	0.205
9	0.942	3.5	3.63	1.207	0.34	0.191

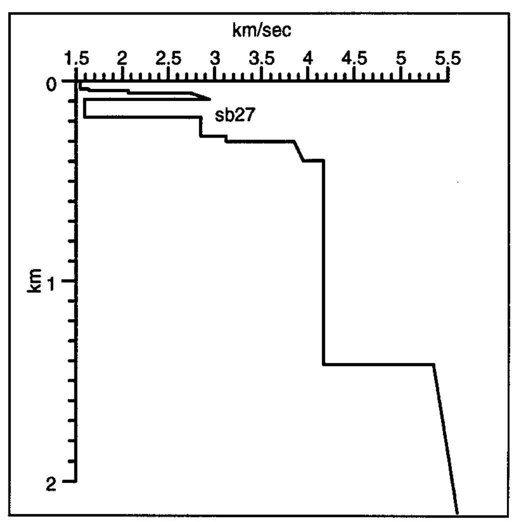
Good buoy



sb27

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.051	1.55	1.55	0.04	0.04	0.051
2	0.058	1.64	1.64	0.045	0.006	0.007
3	0.07	2.069	2.069	0.058	0.012	0.012
4	0.093	2.74	2.94	0.09	0.033	0.023
5	0.203	1.595	1.595	0.178	0.088	0.11
6	0.27	2.85	2.85	0.274	0.095	0.067
7	0.288	3.12	3.12	0.302	0.028	0.018
8	0.337	3.85	3.95	0.397	0.096	0.049
9	0.826	4.17	4.17	1.417	1.02	0.489
10	1.097	5.35	5.61	2.159	0.742	0.271

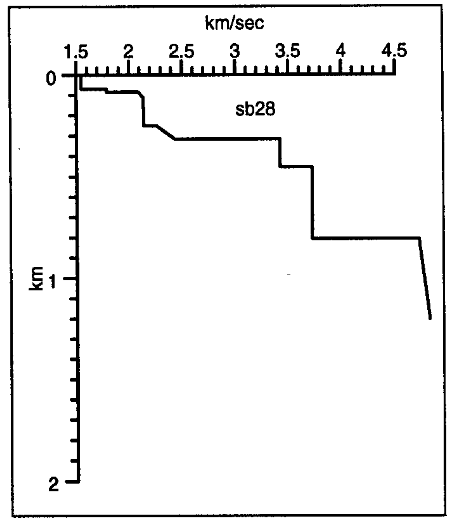
Noisy, but good until 4400 meters, then unusable.



sb28

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.089	1.55	1.55	0.069	0.069	0.089
2	0.105	1.79	1.79	0.083	0.014	0.016
3	0.13	2.09	2.13	0.11	0.026	0.025
4	0.181	2.135	2.135	0.164	0.054	0.051
5	0.261	2.14	2.14	0.25	0.086	0.08
6	0.317	2.26	2.43	0.315	0.066	0.056
7	0.397	3.42	3.42	0.452	0.137	0.08
8	0.587	3.72	3.72	0.806	0.353	0.19
9	0.755	4.72	4.82	1.206	0.401	0.168

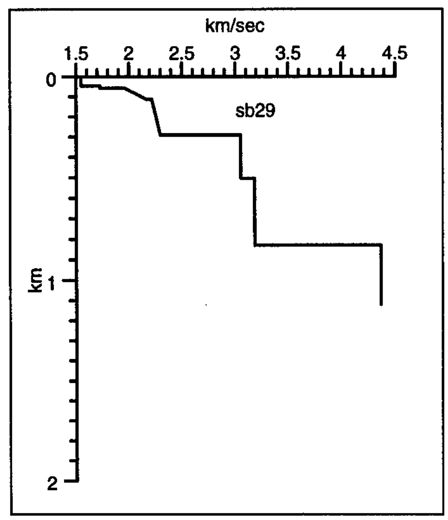
Good – Fair S/N Good range.



sb29

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.059	1.55	1.55	0.046	0.046	0.059
2	0.071	1.725	1.725	0.056	0.01	0.012
3	0.125	1.96	2.17	0.112	0.056	0.054
4	0.282	2.22	2.3	0.289	0.177	0.157
5	0.423	3.05	3.05	0.504	0.215	0.141
6	0.626	3.18	3.18	0.827	0.323	0.203
7	0.762	4.37	4.37	1.124	0.297	0.136

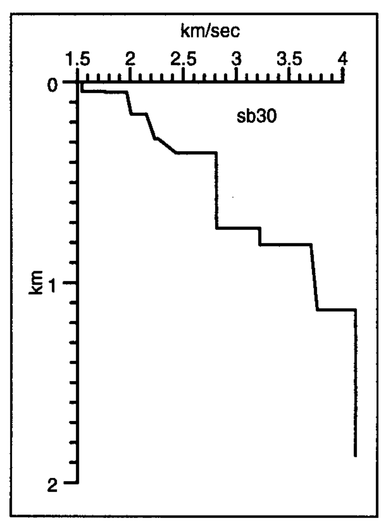
Excellent S/N, longevity.



sb30

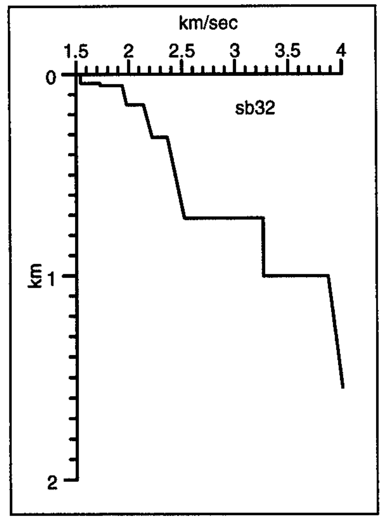
nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.059	1.55	1.55	0.046	0.046	0.059
2	0.063	1.77	1.77	0.049	0.004	0.004
3	0.174	1.97	2.01	0.16	0.11	0.111
4	0.285	2.15	2.23	0.281	0.122	0.111
5	0.345	2.26	2.43	0.352	0.07	0.06
6	0.613	2.81	2.81	0.728	0.377	0.268
7	0.663	3.22	3.22	0.809	0.081	0.05
8	0.838	3.7	3.76	1.135	0.326	0.175
9	1.194	4.12	4.12	1.868	0.733	0.356

Data starts at 280 meters. Good thereafter,
Slight "AGC" effect.



sb32

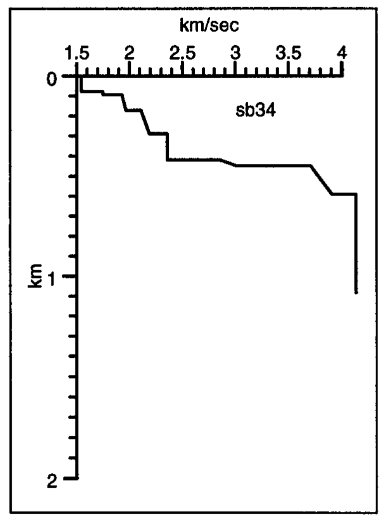
nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.056	1.55	1.55	0.043	0.043	0.056
2	0.069	1.73	1.73	0.055	0.011	0.013
3	0.168	1.94	1.98	0.152	0.097	0.099
4	0.315	2.14	2.22	0.312	0.16	0.147
5	0.645	2.36	2.52	0.714	0.402	0.33
6	0.821	3.26	3.26	1.001	0.287	0.176
7	1.101	3.87	4	1.552	0.551	0.28



Solid buoy. Slight AGC.

sb34

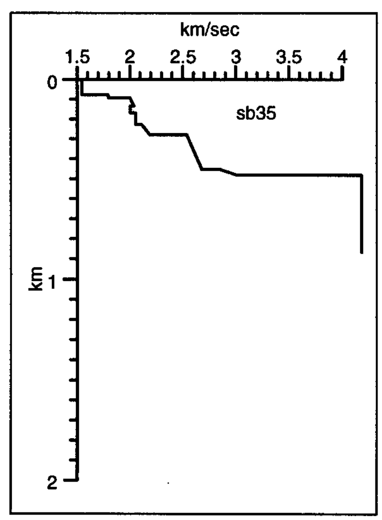
nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.098	1.55	1.55	0.076	0.076	0.098
2	0.117	1.75	1.75	0.093	0.017	0.019
3	0.197	1.93	1.97	0.171	0.078	0.08
4	0.305	2.11	2.19	0.287	0.116	0.108
5	0.416	2.355	2.355	0.417	0.131	0.111
6	0.436	2.85	3.01	0.447	0.029	0.02
7	0.512	3.705	3.905	0.591	0.145	0.076
8	0.752	4.13	4.13	1.087	0.496	0.24



Starts well, noise takes over at 3500 meters.

sb35

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.098	1.55	1.55	0.076	0.076	0.098
2	0.117	1.8	1.8	0.093	0.017	0.019
3	0.157	2	2.04	0.133	0.04	0.04
4	0.19	2.005	2.005	0.167	0.033	0.033
5	0.248	2.057	2.057	0.226	0.059	0.058
6	0.298	2.11	2.19	0.28	0.054	0.051
7	0.431	2.535	2.675	0.453	0.173	0.133
8	0.45	2.85	3.01	0.481	0.028	0.019
9	0.635	4.18	4.18	0.868	0.387	0.185

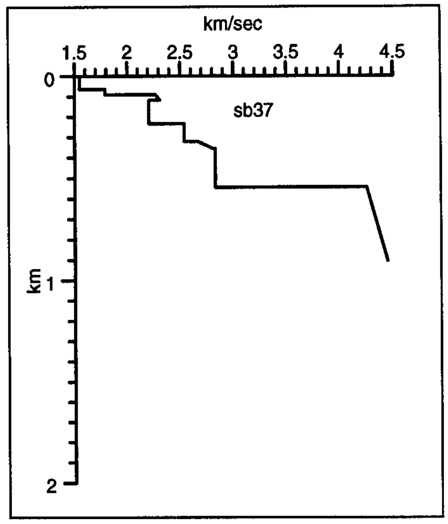


Good buoy with slight amplitude shift, some AGC.

sb37

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.082	1.55	1.55	0.064	0.064	0.082
2	0.112	1.795	1.795	0.09	0.027	0.03
3	0.135	2.27	2.31	0.117	0.026	0.023
4	0.239	2.207	2.207	0.232	0.115	0.104
5	0.307	2.536	2.536	0.318	0.086	0.068
6	0.334	2.665	2.805	0.355	0.037	0.027
7	0.467	2.825	2.825	0.543	0.188	0.133
8	0.635	4.25	4.45	0.908	0.365	0.168

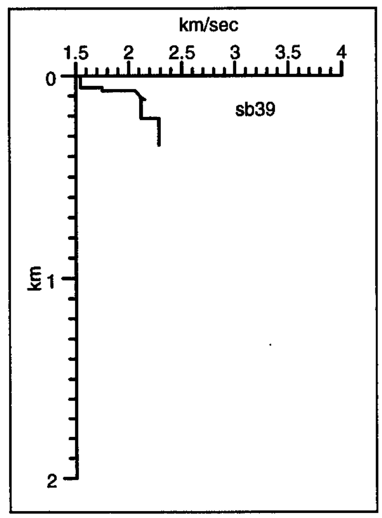
Good buoy. Slight "AGC"



sb39

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.076	1.55	1.55	0.059	0.059	0.076
2	0.094	1.75	1.75	0.075	0.016	0.018
3	0.123	2.065	2.115	0.105	0.031	0.03
4	0.135	2.11	2.15	0.118	0.012	0.012
5	0.224	2.117	2.117	0.212	0.094	0.089
6	0.343	2.285	2.285	0.348	0.136	0.119

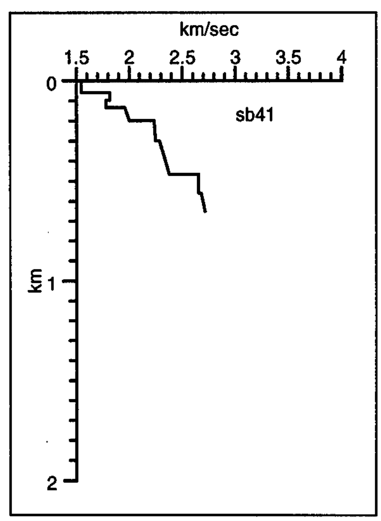
Very Poor – See Fig. 1



sb41

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.077	1.55	1.55	0.06	0.06	0.077
2	0.117	1.82	1.82	0.096	0.036	0.04
3	0.159	1.78	1.78	0.133	0.037	0.042
4	0.222	1.96	2	0.196	0.062	0.063
5	0.311	2.237	2.247	0.296	0.1	0.089
6	0.458	2.286	2.376	0.466	0.171	0.147
7	0.528	2.65	2.65	0.559	0.093	0.07
8	0.598	2.675	2.714	0.654	0.095	0.07

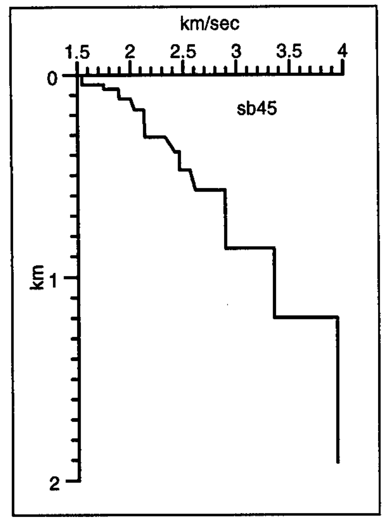
Noisy, Poor amplitude response, first arrivals OK, for some reason.



sb45

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.062	1.55	1.55	0.048	0.048	0.062
2	0.087	1.75	1.75	0.07	0.022	0.025
3	0.14	1.89	1.9	0.12	0.05	0.053
4	0.193	2	2.04	0.174	0.054	0.053
5	0.32	2.127	2.137	0.309	0.135	0.127
6	0.382	2.326	2.416	0.383	0.073	0.062
7	0.457	2.46	2.46	0.475	0.092	0.075
8	0.532	2.555	2.605	0.572	0.097	0.075
9	0.731	2.885	2.885	0.859	0.287	0.199
10	0.933	3.345	3.345	1.196	0.338	0.202
11	1.298	3.935	3.935	1.915	0.718	0.365

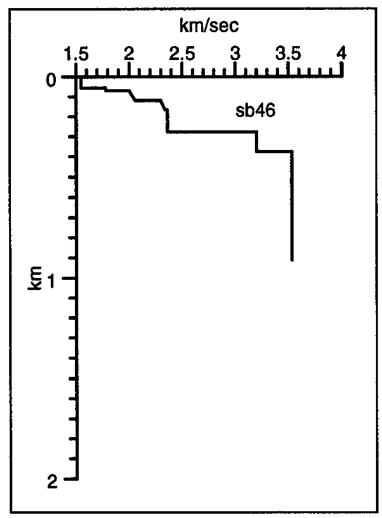
Fair S/N, good arrivals



sb46

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.07	1.55	1.55	0.054	0.054	0.07
2	0.089	1.78	1.78	0.071	0.017	0.019
3	0.136	2	2.06	0.119	0.048	0.047
4	0.176	2.3	2.34	0.165	0.046	0.04
5	0.271	2.361	2.361	0.277	0.112	0.095
6	0.332	3.203	3.203	0.375	0.098	0.061
7	0.638	3.53	3.53	0.915	0.54	0.306

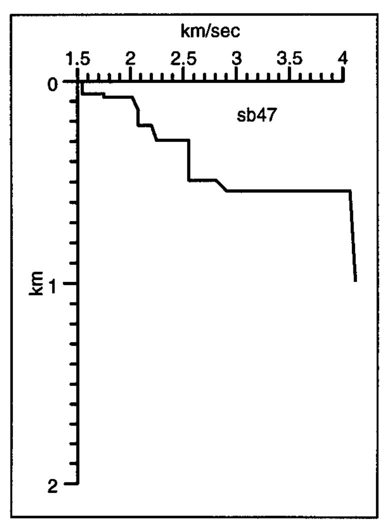
Good S/N, but periodic "stripes" of noise (probably ship-generated.)



sb47

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.079	1.55	1.55	0.061	0.061	0.079
2	0.1	1.75	1.75	0.08	0.018	0.021
3	0.164	2.019	2.079	0.145	0.066	0.064
4	0.234	2.073	2.073	0.218	0.073	0.07
5	0.304	2.197	2.247	0.295	0.078	0.07
6	0.459	2.55	2.55	0.493	0.198	0.155
7	0.494	2.807	2.908	0.543	0.05	0.035
8	0.713	4.065	4.115	0.991	0.448	0.219

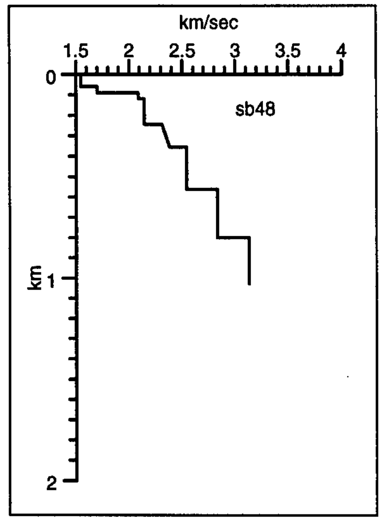
Weak signal, but excellent S/N.



Sb 48

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.078	1.55	1.55	0.06	0.06	0.078
2	0.114	1.7	1.7	0.091	0.031	0.036
3	0.14	2.09	2.09	0.118	0.027	0.026
4	0.256	2.145	2.145	0.243	0.124	0.116
5	0.352	2.312	2.382	0.355	0.113	0.096
6	0.515	2.54	2.54	0.562	0.207	0.163
7	0.682	2.825	2.825	0.798	0.236	0.167
8	0.832	3.125	3.125	1.033	0.234	0.15

Excellent S/N, 7 km max range



sb49

nl	T0	VTOP	VBOT	ZTOTAL	DZ	DT
1	0.055	1.55	1.55	0.043	0.043	0.055
2	0.125	1.75	1.75	0.104	0.061	0.07
3	0.16	2.09	2.09	0.14	0.037	0.035
4	0.194	2.12	2.17	0.177	0.036	0.034
5	0.338	2.295	2.295	0.342	0.165	0.144
6	0.461	2.52	2.52	0.497	0.155	0.123
7	0.693	3.675	3.675	0.923	0.426	0.232

Excellent S/N